Modelling extreme flood hazard events on the middle Yellow River using DFLOW-flexible mesh approach

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We would like to thank the Reviewer 2 for taking time in reading and evaluating the above mentioned manuscript.

Answers to specific comments and recommendations of the reviewer follow:

Major comments: *In the paper the authors intend to present a new modelling approach for flood propagation in natural rivers. The new proposal, essentially, focus on the use of "flexible" mesh for geometric description of the flow domain. As matter of fact, the paper addresses an interesting topic but in my opinion, the approach used by the authors to analyze the problem is, in many aspects, not correct.*

Authors' answer: We would like to thank the reviewer for evaluating the article as of interest and we are sorry for the unclearness that we will address hopefully in the answers to these comments, as well as in the improved version of the manuscript. We do address all the comments raised by the reviewer one by one below.

Comment 1: *First, I found confusing the use of the term "flexible mesh" (in the title and in some parts of the manuscript) when a model which using an unstructured grid is presented. Actually, flexible mesh is used for those models which implements dynamic meshing (i.e., a* *mesh which varies its geometric characteristics during the simulation. I certainly agree unstructured grids are definitively more capable to describe the geometric peculiarities of natural floodprone areas then old-fashioned structured grids. But this is not a novelty in the scientific and technical literature as many research and commercial models are available (it is quite strange the absence in the list of references of many authors involved in this topic, Bates P.D for instance). So, if the author's intention was to compare the performances in using these two different modelling approaches I haven't found anything in the paper related to this. Again, if the intention was to present a new mathematical development of the problem, it is quite bizarre how any equations is reported in the manuscript.*

Authors' answer: Thank you for your questions. The term "flexible mesh" was used because the tool developed by Deltares uses this as a defining term for their tool. Indeed this may not be fully in line with the majority accepted terms and we will rephrase the title or redefine the notion of flexible, as it is understood by the developers of the tool, making the title clearer to the reader.

The intention of the authors was not to make a comparison, but to show that such a tool is able to capture flood phenomena for large complex rivers, that are not normally captured by other tools. We will make this goal very clear in the introduction section of the paper.

For example results are able to capture the hanging river characteristic of Yellow River, which generates a complex flooding process. When large amounts of water overflow the summer dykes, flood is carried until it reaches the winter dykes. Then, slow moving waters are rapidly conveyed along the dykes with the topography developing a sub flooding process.

This feature has not been found anywhere else in the literature of the Yellow River (Guoying, 2010; Li, 2013) and it is an interesting feature present in the area, during flooding events, which could be captured with such a model.

The main focus of the presented research of the manuscript was to evaluate if DFLOW, an existing software tool developed by Deltares, is able to properly represent flooding events on Yellow River. The tool is solving the classical shallow water Saint Venant equations using an approach based on unstructured grids. The authors did not develop the tool, nor did they want to present the numerical algorithms implemented in DFLOW-FM, because they have been elaborated in two other articles, by the developers of the tool themselves. These two references are:

Kramer, S., Stelling, G.,: A conservative unstructured scheme for rapidly varied flows. *International Journal of Numerical methods for fluids*, 58, 183–212, 2008

—Kernkamp, H., Dam, A., Stelling, G., Goede, E.,: Efficient scheme for the shallow water equations on unstructured grids with the application to the continental shelf. *Ocean Dynamics* 27 61 (8), 1175-1188, 2011

However because both reviewers raised the issue of having more details in the numerical approach addressed, in the final version of the manuscript the authors will extend the text with a summary of the theoretical points regarding the numerical approach as presented in the two above mentioned papers, in order to make the paper clearer.

Our reference to the existing literature did not intend to leave any author out, but given the goal of the research, some references were not included. We are well aware of the work of P. Bates, but since the scope was the flooding for extreme events, not yet recorded on Yellow river, we did not make this link. We will include the reference in the new version of the manuscript, as per request.

Comment 2: *Regarding the proposed application I found many significant weak points:*

Authors' answer: The authors are thanking the reviewer for pointing out that these issues are not clearly explained in the manuscript. These are be addressed one by one bellow:

1) A calibration of the model is completely missing. The authors say they use a single roughness value (page 9, line 240) both for river as for lowland areas. But for a such large area (1,936 km^2) this is, in my opinion, unacceptable.

Authors' answer: The methodology used for the calibration of a flooding event, is done based on the currently applied procedure at YRCC, i.e. looking at the behaviour of the Yellow River, in case of a flooding event that has a peak discharge equal or larger than 4,000m^3/s. Calibration followed this approach and estimation of the Manning roughness coefficient was determined, in such a way to guarantees that water is contained inside the main reach of the river for the above mentioned specific flooding event. This was the only information available for developing the unstructured model.

2) How it was possible to test and check the reliability and robustness of the model is any comparison of model outputs with a real event has been carried out

<u>Authors answer:</u> The overall performance with respect to measured events in the present research focused on a set of 339 extreme events generated synthetically and no measurements of such events are available at YRCC yet, due to their extreme nature. Hence the analysis related to the reliability and robustness of the model with respect to real events is not yet possible because there is no flood map, aero photo or satellite image available to perform a singular analysis in each of the 339 synthetically generated simulation cases.

The authors are mentioning in the introduction of the manuscript this issue and are pleading for the fact that such research is still useful for a highly intervened stream such as Yellow river in climate change conditions.

The use of design hydrographs and a flooding calibration to a single event seems not to be according with reality, due to the spatial variation of the flooding event and flooding volume when a new hydrograph appears. This is presented in figure 12 and 13 of the manuscript.

3) It is quite obscure how the hydrographs used for the simulations has been derived (page 10, line 271). What do the authors intend with "inference model"?

Thank you for pointing out to us this omission. The upstream boundary conditions are generated using a reservoir operation model, which encapsulates the rules and behaviour of the reservoir system as defined by YRCC. This reservoir operation model generates a flood hydrograph at Huayuankou station based on synthetic Gamma function hydrographs input into reservoirs; rule operation of the reservoirs and flow routing on the downstream branches between reservoirs and Huayuankou station. This part of the research is not detailed because it has been presented as a separate paper in another journal related to statistical inference and input variable selection in surrogate models for reservoir operations. In the new version of this manuscript we will properly summarise these in order to make the paper comprehensible.

Comment 3: *Last but not least, the quality of the language is not satisfactory at all, thus a in-depth review of the grammar and writing style should be done.*

Authors' answer: We are currently checking once again the manuscript from grammar and punctuation point of view as well as explaining in a concise manner the content of the manuscript. This is done primarily by one of the authors whom happen to be a native English speaker. Taking very seriously the advice of the reviewer currently, as well, a specialist in Technical English writing is checking the paper. We hope that the revised manuscript, which will be submitted for the consideration of Reviewers and the Editor, at the end of the Interactive discussion will meet the requirements of the reviewer.

Remark: All our responses to the questions raised by the referee will be included in the revised version of the manuscript.

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